



User Manual

## LucidControl – Product Series

# 1 Introduction

This document contains all information necessary to work with the LucidControl Product Series.

It describes hardware, setup as well as the general functionality of the products. This document should be used together with the user manual describing the detailed module functions.

All LucidControl modules share some properties (like same housing, or communication protocol). Some properties are dependent on the functionality of the modules (e.g. the input signals and the signal processing of inputs and outputs). This documentation concentrates on the common properties.

The following documentation is available for LucidControl modules:

- General LucidControl Manual (this document)
- Specific LucidControl Module User Manual describing the module functionality
- Specific One Sheet Manual giving a fast introduction to the LucidControl modules

## 1.1 What is LucidControl?

The LucidControl product family consists of various IO modules for processing of digital and analog signals with a computer. It can capture digital inputs e.g. from an automation control as well as it can measure analog signals like voltages or temperatures.

Moreover the module is able to interface control systems like PLCs by generating digital signals and it can also control electrical loads directly e.g. by switching them on and off.

Analog signals (e.g. 0 ... 10 Volt Interfaces) created by the LucidControl modules can be used for controlling purposes as well.

Typically a module of the LucidControl series can handle 4 inputs or outputs of the same signal type (e.g. analog inputs)

For operation all modules of the LucidControl series only need a connection to a computer. Since all modules are powered by the USB an additional power supply is not required.

The modules are very easy to use because the same software tools can be used for all of them. Once the module is connected to the computer it starts working immediately. And

thanks to the standardized device driver which is included in most operating systems the modules out of the box without driver installation.

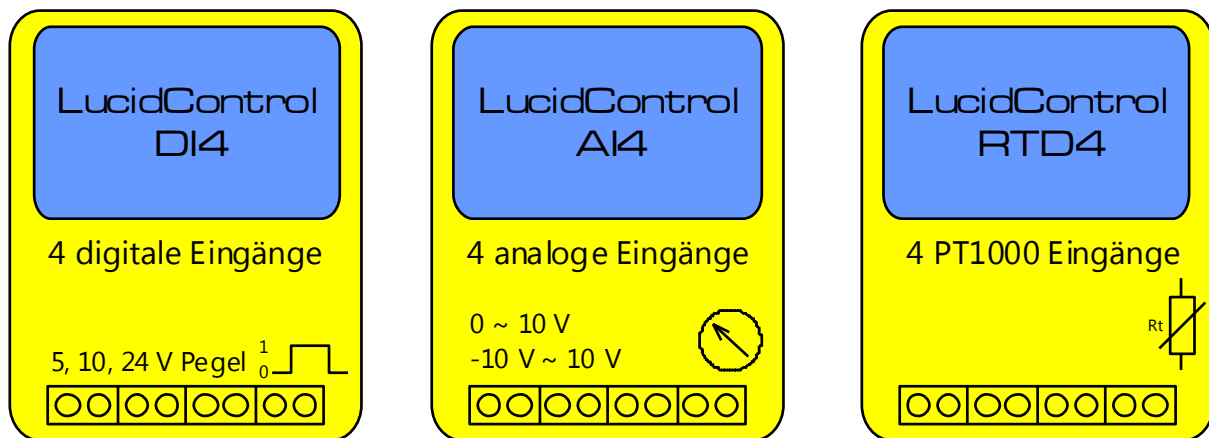
Working with LucidControl modules is absolutely straight forward. Using the LucidIoCtrl command line tool gives full access to all functions where does not matter how many modules are connected to the computer.

The modules are equipped with industrial ready IO terminals and can be used in various applications like domestic engineering energy management or general automation applications.

LucidControl modules are made to work with most computers running Windows® or Linux. While this is true for most desktop computers and notebooks the module is moreover optimized for embedded computers and compatible with the popular **Raspberry Pi®** which gives lots of additional applications because of its open development, enormous community and of course it's reasonable price.

## 1.2 LucidControl Product Family

Fig. 1 and Fig. 2 show the available input modules of the LucidControl Product family.



**Fig. 1 LucidControl Input Modules**

### LucidControl DI4 – Digital Input USB Module

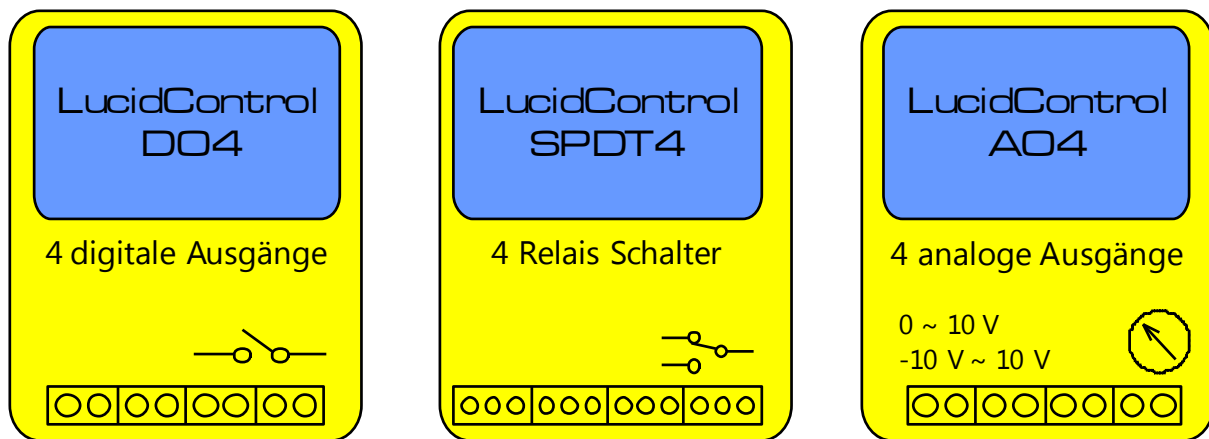
This module provides 4 opto-insulated and potential-insolated digital inputs. It is available for different input voltages in order to cover a wide range of applications.

### LucidControl AI4 – Analog Input USB Module

This module provides 4 analog inputs. The module is available for various input voltage ranges and is able to measure analog voltages e.g. as they are used in 0 ~ 10 V interfaces.

### LucidControl RTD4 – RTD Input USB Module

This input module measures the temperature of 4 Pt1000 temperature sensors (RTD).



**Fig. 2 LucidControl Output Modules**

#### LucidControl DO4-I – Digital Output USB Module

This module controls 4 digital opto-insulated and potential-insulated outputs by using solid state relays which give best overall performance for most applications.

#### LucidControl DO4-O – Digital Output USB Module

This module controls 4 digital open collector outputs.

#### LucidControl DO4-S – Digital Output USB Module

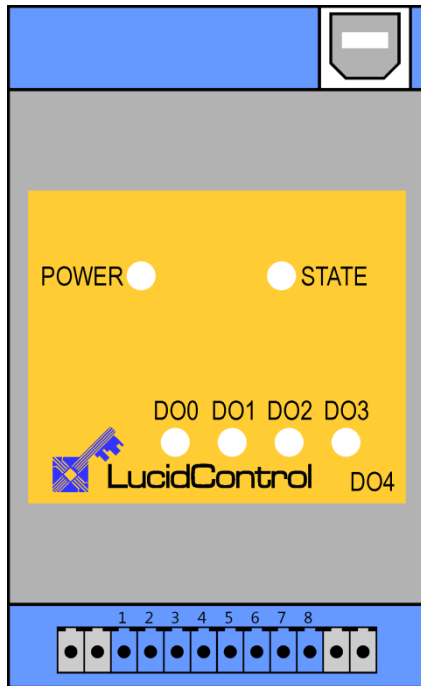
This module controls 4 SPDT relays which can be used for switching loads. It is also useful for toggling between two analog signals like temperature sensors.

#### LucidControl AO4 – Analog Output USB Module

This module controls 4 analog voltage or current outputs and is available for various ranges. It can be used to generate general purpose signals as well as to communicate with 0 ~ 10 V interfaces.

For all of these devices a module specific User Manual is available which may refer to this document and vice versa.

## 2 Setup and Installation



**Fig. 3 LucidControl Schematic**

Fig. 3 shows the LucidControl Digital Output Module with 4 digital outputs (DO0 ~ DO3).

All LucidControl modules have only two connectors, the USB-Connector and the IO-Connector. Because of this the modules are very easy to connect and to set-up.

While the upper USB-Connector is used for interconnection with the computer, the lower IO-Connector provides the interface accordingly to the module function (e.g. digital outputs or analog inputs).

The IO-Connector of most modules have 8 terminals, two for each input or output channel. One exception is the DO4-S module which has 3 terminals for a one output

channel and provides an IO-Connector with 12 contacts (illustrated in gray).

### 2.1 Interface and Interconnection

#### 2.1.1 USB Connection

LucidControl USB modules are connected to the computer by using a standard USB Cable which must not extend a length of 5 m.

All modules are "bus powered" which means that the host computer supplies the module with power and there is no additional power supply necessary.

##### Note

Supplying USB devices with power is not critical using a desktop computer or notebooks but it must be considered that the total power of one USB port is limited to 500 mA.

The USB ports of the Raspberry Pi® are limited to 100 mA. This means that maximum two devices can be connected to a port directly.

All LucidControl are rated a maximum Current which can be found in the module specific user manual.

### Note

Using an active USB-Hub with its own power supply allows the connection of additional devices in the case that the host is not able to supply them.

## 2.1.2 IO Connection

The signals applied to the IO-Connector must be compatible with the function of the module.

The correct interconnection is described in the module specific section "IO Connection" of the module specific user manual.



All contacts of the modules are protected against ESD but not necessarily against overload which is especially relevant for output modules.



If the module specific user manual does not state anything different it is under no circumstances allowed to apply voltages above 30 V or below -30 V to any terminal. This may destroy the module.

## 2.2 Mechanical Setup

Text needed

## 2.3 Software Setup

Setting up of LucidControl modules is very easy and described in the following for Microsoft Windows<sup>®</sup> and Linux operating systems:

- 1 At first ensure that no signal is applied to the IO-Connector
- 2 Connect LucidControl via USB with your computer
- 3 Applies for Microsoft Windows<sup>®</sup> only:

The system asks for an installation file. This is not a driver but only an information file (INF). The file can be download from our website:

[www.lucid-control.com](http://www.lucid-control.com)

- 4 That's all. The green power LED is on and the module is ready for use.

### 2.3.1 Microsoft Windows®

As mentioned the installation under Microsoft Windows requires the information file.

After installation the Windows Device Manager contains a new serial port (COM). The module can be accessed using this port.

Note:

Even if more than one module is connected to a computer Microsoft Windows® ensures that the same serial port number is assigned to the module(s) after start up.

### 2.3.2 Linux

Despite to Microsoft Windows® installation under Linux the module is ready immediately after connection without any additional steps. Linux installs /dev/ttyACM devices for any module connected to the computer incrementing the succeeding number for any device starting with 0.

Note:

By default Linux cannot ensure that the same /dev/ttyACM device is assigned the same module after a restart. But as long as only one module is connected to the computer it is ensured that it is accessible via /dev/ttyACM0.

LucidIoCtrl Command line tool can create a permanent static link to a unique LucidControl. This link is also present after a restart and it can also have a more meaningful device name like dev/digitalIoKitchen.

### 2.3.3 Installation of LucidIoCtrl Command Line Tool

For different architectures the LucidIoCtrl Command Line Tool (LCLT) can be found on our website:

[www.lucid-control.com](http://www.lucid-control.com)

After downloading the program can be stored in a folder of choice.

### 2.3.4 Ready to Take-Off

Once the module was installed successfully (if it was necessary at all) the green Power LED is switched on signaling that the module is ready for use.

The following examples illustrate how to access a LucidControl module by using LCLT. The Identify command (see section 4.3.8) is used to request specific information of the module e.g. type, serial number, etc.

At this moment it is only important to know that the Identify command can be used to inspect all LucidControl modules and all modules provide similar information.

### Windows Example

This example assumes that the LucidControl module is connected to comport 1.

Enter the following line in the windows prompt (console):

```
LucidIoCtrl -dCOM1 -i [ENTER]
```

### Linux Example

This example assumes that the LucidControl module is connected to /dev/ttyACM0.

Enter the following line in the console:

```
LucidIoCtrl -d/dev/ttyACM0 -i [ENTER]
```

### Result of both Examples

LCLT returns a console output similar to what can be seen below:

```
DEVICE CLASS:      1000          (DIGITAL OUTPUT 4 CHANNELS)
DEVICE TYPE:       1000          (SOLID STATE 24 V)
SERIAL NUMBER:     02000000
FIRMWARE REVISION: 0001
HARDWARE REVISION: 01
```

The output above represents the result of the Identify command from a digital output module with 4 channels carried out as solid state relays (SSR).

In case of an error the chosen comport is probably wrong and the parameter should be revised.

## 3 LucidIoCtrl Command Line Tool (LCLT)

### 3.1 Introduction

The LucidIoCtrl Command Line Tool grants easy and complete access to all functions of LucidControl.

The easiest way to invoke LCLT is by opening a console or logging in by SSH. LCLT gives immediately access to all LucidControl modules connected to the host computer.

LCLT was designed in order to provide a tool which runs standalone without depending on any library and which is available for all architectures. The tool runs under Microsoft Window<sup>®</sup> and Linux. Copying the executable file to the host computer is all needed to do.

Moreover command line tools can be integrated into nearly all applications. It does not matter if PHP, Python, C#, Java or any other programming language is used. All of them have the ability to run console application and to evaluate their output.

With this tool the user gets a lightweight Application Programming Interface (API) for LucidControl that can be used even without programming knowledge by entering the commands into the shell.

Let's take the following example

It is assumed that the LucidControl module is connected to COM4  
The output channel 0 of a digital output module should be set.

Running Microsoft Windows<sup>®</sup> prompt entering the line:

```
LucidCtrl -dCOM4 -c0 -w1 -tL [ENTER]
```

Or by entering this to the Linux shell when LucidControl is connected to /dev/lucidIoKitchen:

```
./LucidCtrl -d/dev/lucidIoKitchen -c0 -w1 -tL [ENTER]
```

Both examples set the output to 1.

The details of the commands are described in the following sections but here it should be explained how easy it is to work with LucidControl.

Assuming that the lines are included into a PHP script running in a webserver it is quite obvious that LucidControl can be accessed via the internet very easily.

## 3.2 LCLT Arguments

LCLT is controlled by arguments succeeding the program name as it is usual for command line tools. These arguments are split into two groups:

- Command Arguments (Command Arguments 3.2.1)
- Option Arguments (3.2.2)

### 3.2.1 Command Arguments

Command Arguments specify which command should be executed. Only one command argument is allowed to be used when calling LCLT.

Argument	Description
-a	I/O Calibration
-g	Read Parameter
-i	Identify Device
-r	Read I/O Channel(s)
-s	Write Parameter
-w	Write I/O Channel(s)

**Tab. 1 Command Arguments**

Tab. 1 shows all available Command Arguments with their short description. They are described in this section.

#### 3.2.1.1 --write, -w

The Write command assigns values to output channels.

##### Function Call:

```
./LucidIoCtrl -dDEVICE -wValue(s) -cChannel(s) -tValueType [ENTER]
```

##### Examples:

This command sets output channel 0 (-c0) to 0 (-w0). Since a digital output is accessed the value can be either 0 or 1 (-tL). This is the typical function call for setting a digital output:

```
./LucidIoCtrl -d/dev/LucidIo -w0 -c1 -tL [ENTER]
```

This command sets the analog output 2 (-c2) to a voltage (-tV) of -5.000 V (-w-5.000):

```
./LucidIoCtrl -d/dev/LucidIo -w-5.000 -c2 -tV [ENTER]
```

This command sets the analog output 3 (-c3) to a current (-tC) of 2.5 mA (-w2500):

```
./LucidIoCtrl -d/dev/LucidIo -w2.500 -c3 -tC [ENTER]
```

This example shows that it is also possible to set the values of multiple outputs by one single function call:

```
./LucidIoCtrl -dLucidIo -w2.500,5.000,1.250 -c1,2,0 -tV [ENTER]
```

The function call above sets the analog output 0 to 1.250 V, output 1 auf 2.500V and output 2 to 5.000 V. It must be considered that channels and values must be ordered the same way.

The Write command is able to access different value types like logical, counters or analog voltages. Please see section 3.2.2.3 for further information about value types of the LCLT and see also the module specific documentation on information about supported value types.

In the case of successful execution, the Write command finishes without returning information (on the output console). In the case of error please see section 3.3 for more information.

### 3.2.1.2 --read, -r

The Read command returns the input values of inputs. It can only be used to read the current state of outputs. The returned value is formatted accordingly to the requested value type.

#### Function Call

```
./LucidCtrl -dDEVICE -r -cChannel(s) -tType [ENTER]
```

#### Examples

This example reads channel 1 (-c1) of a digital input. It can also be used in order to read the state of a digital output:

```
./LucidCtrl -d/dev/LucidIo -r -c1 -tL [ENTER]
-> CH1:00
```

The Read command returns the value in a formatted form. In the example above the channel 1 (CH1) is not set.

The following example reads analog voltages from the channels 0, 1 and 2. The returned values are in ascending order:

```
./LucidCtrl -d/dev/LucidIo -r -c2,0,1 -tV [ENTER]
-> CH0:1.250 CH1:2.500 CH2:5.000
```

The Read command is able to access different value types like logical, counters or analog voltages. Please see section 3.2.2.3 for further information about value types of the LCLT

and see also the module specific documentation on information about supported value types.

In the case of successful execution, the Read command returns the requested values. In case of error please see section 3.3 for more information.

### 3.2.1.3 --setparam, -s

The Set Parameter command sets Configuration Parameters of the LucidControl module and the IO Configuration Parameters of inputs or outputs.

#### Function Call

```
./LucidCtrl -dDEVICE {-cChannel(s)} -sParameter=Value {-p} {-y} [ENTER]
```

In the case that the Parameter is related to an input or output, the channel can be passed with the Option Argument -c.

With the Option Argument -p the setting can be made persistent so that it is loaded after the restart of the module (see section 3.2.2.6).

The Option Argument -y sets the parameter back to the default value (see section 3.2.2.7).

The Option Arguments -p and -y can be combined in order to restore the default setting permanently.

#### Example

This example switches led blinking for incoming commands on. The Status LED blinks on any received command indicating communication:

```
./LucidCtrl -d/dev/LucidIo -ssysSignalCmd=on [ENTER]
```

This example configures the digital input channel 0 for Reflect mode:

```
./LucidCtrl -d/dev/LucidIo -c0 -sinDiMode=reflect [ENTER]
```

A detailed description of all parameters supported by the module and its inputs or outputs can be found in the "Parameters" section of the module specific user manual.

In the case of successful execution, the Set Parameter command finished without returning an output (e.g. on the console). In the case of error please see section 3.3 for more information.

### 3.2.1.4 -getparam, -g

The Get Parameter command reads Configuration Parameters of the LucidControl module and the IO Configuration Parameters of inputs or outputs.

### Function Call

```
./LucidCtrl -dDEVICE {-cChannel(s)} -gParameter [ENTER]
-> Parameter=Value
```

### Example

This example returns the configuration of digital input channel 0:

```
./LucidCtrl -d/dev/LucidIo -c0 -ginDiMode [ENTER]
-> inDiMode=reflect
```

A detailed description of all parameters supported by the module and its inputs or outputs can be found in the "Parameters" section of the module specific user manual.

This function call returns the value of a parameter.

In the case of successful execution, the Get Parameter command returns the parameter name and the parameter value. In the case of error please see section 3.3 for more information.

### **3.2.1.5 --calibrate, -a**

The Calibrate IO command starts calibration of LucidControl.

### Function Call

```
./LucidCtrl -dDEVICE {-cChannel(s)} -a {-q} [--short] [--open] [ENTER]
EXECUTE I/O CALIBRATION FOR CHANNEL ... ? <y/n> [ENTER]
```

In the case that the optional -q Option Argument is used the Calibrate IO command is executed immediately without asking for user confirmation. Otherwise the application requires confirmation of the user before it proceeds with calibration.

When a specific channel has to be calibrated it can be specified by the -c Option Argument. Most modules need this parameter.

### Example

This example calibrates the input channel 0 of e.g. an analog input module without user confirmation:

```
./LucidCtrl -dLucidIo -c0 -a -q [ENTER]
```

In the case of successful execution, the Calibrate IO command finished without returning an output. In the case of error please see section 3.3 for more information.

### 3.2.1.6 --identify, -i

The identify command returns general module information and is supported by all modules.

#### Function Call

```
./LucidCtrl -dDEVICE -i [ENTER]
->  DEVICE CLASS:      xxxx          (Device Class Description)
->  DEVICE TYPE:       1000          (Device Type Description)
->  SERIAL NUMBER:     xxxxxxxx
->  FIRMWARE REVISION: xxxx
->  HARDWARE REVISION: xx
```

The identify command returns:

- Device Class declaring the functionality of the module in common e.g. 4 digital inputs or 4 analog outputs
- Device Type declaring the type of device e.g. 5V inputs for a digital input module
- The Serial Number is a unique 4 byte hexadecimal number
- Firmware and hardware revision of the LucidControl module

#### Example

This example returns general module information:

```
./LucidCtrl -d/dev/LucidIo -i [ENTER]
->  DEVICE CLASS:      0000          (DIGITAL INPUT 4 CHANNELS)
->  DEVICE TYPE:       1000          (5 V)
->  SERIAL NUMBER:     DDCCBBAA
->  FIRMWARE REVISION: 0001
->  HARDWARE REVISION: 01
```

This example shows the typical output of LucidControl DI4-I-5. It provides 4 digital input channels with 5V threshold level.

In the case of successful execution, the Identify command returns the shown information. In the case of error please see section 3.3 for more information.

### 3.2.2 Option Arguments

Option Arguments specify additional settings for a Command Argument.

The following table shows all available Option Arguments with their short description:

Argument	Description
-b	Baudrate
-c	Channel
-d	Device
-h	Help
-p	Persistent
-q	Quiet
-t	Value Type
-y	Default Value

**Tab. 2 Option Arguments**

### 3.2.2.1 --channel, -c

The Option Argument Channel specifies the input or output channel for a Command Argument. It is mandatory for the commands Read and Write.

It is also mandatory for Command Arguments Set Parameter, Get Parameter and Calibrate IO in the case that an input or output channel has to be configured or calibrated.

### 3.2.2.2 --device, -d

The Option Argument Device specifies the device name of the LucidControl module. It is mandatory for all Command Arguments.

#### Examples

For Microsoft Windows® operating system COM4 could be a valid device name (-dCOM4).

For Linux operating systems /dev/ttyACM0 could be a valid device name (-d/dev/ttyACM0).

#### Note

For Microsoft Windows® LucidControl may use comports COM10 or higher. For these high numbered comports the device argument must be changed since -dCOM10 does not work for them.

The correct argument in this case is -d\\.\COMnn which can be used for any comport. If COM10 should be accessed -d\\.\COM10 is the correct notation.

### 3.2.2.3 --type, -t

The Option Argument Value Type specifies the value type of Read and Write Command Arguments and is mandatory for those.

The supported Value Types are listed in Tab. 3. Depending on the module type one or more Value Types are supported. A digital input module for example has support for Value

Type "L" since it provides logical inputs. But it does not support Value Type "V" because there is no analog voltage input available.

<b>Value Type</b>	<b>Value Range and Format</b>	<b>Description</b>
<b>L</b> (0x00)	„00“ or „01“ Format Example: CH0:01	Digital Logic Value
<b>N</b> (0x0A)	0 ~ 65535 Format Example: CH0:0x0064 (100)	Digital Counter Value
<b>A</b> (0x10)	0 ~ 65535 Format Example: CH0:0x0064 (100)	Analog Value
<b>V</b> (0x1D)	- 100.000 ~ 100.000 V Format Example: CH0:-5.000	Voltage Value (signed)
<b>C</b> (0x23)	-1000.000 ~ 1000.000 mA Format Example: CH0:-20.000	Current Value (signed)
<b>T</b> (0x41)	- 1000 ~ 1000 °C Format Example: CH0:18.000	Temperature Value (signed)
<b>R</b> (0x50)	0 ~ 5000 Ω Format Example: CH0:2500.0	Resistance Value

**Tab. 3 Value Types**

The Value type (bold printed letter) which is passed to the -t Option Argument is translated to the byte value in parentheses. Section 4.2 gives more information how the different Value Types are handled by LucidControl.

### 3.2.2.4 --help, -h

The Option Argument Help returns a help page for a Command Argument and is optional.

### 3.2.2.5 --default, -y

The Option Argument Default sets a Configuration Parameter to the default setting. It is optional for the Set Parameter Command Argument.

All parameters have default settings which allow resetting a specific setting to a standard value.

### 3.2.2.6 --persistent, -p

The Option Argument Persistent stores a Configuration Parameter value. The setting will be restored after a restart. It is optional for the Set Parameter Command Argument.

### 3.2.2.7 --quiet, -q

The Option Argument Quiet suppresses the user confirmation message before executing a command. It is optional for the Calibrate IO Command Argument and skips the user confirmation.

#### **3.2.2.8 --baudrate, -b**

The Option Argument Baudrate specifies the communication speed of the used device. It is optional and not necessary or supported by LucidControl USB modules which use a default value of 9600 baud.

#### **3.2.2.9 --verbose**

The Option Argument Verbose Mode generates additional console output used for testing purposes. It is optional for all Command Arguments.

### **3.3 Return Values**

LCLT returns different return values depending on the result.

The command line tool returns an Exit Code which indicates if the tool finished with success (Exit Code = 0) or with error (Exit Code = -1).

#### **3.3.1 Successful Execution**

In the case that the execution of the command was successful the Exit Code is set to 0 and the tool may return data depending on the executed command.

#### **3.3.2 Error Codes**

In the case of an error the Exit Code of the command line tool is set to -1. Moreover the tool may return some more meaningful error information.

There are two reasons why a command is not executed successfully:

1. The arguments passed to LCLT are not correct and the program returns an Error Status Code.
2. LucidControl module returns an Error Status Code because of not successful execution.

##### **3.3.2.1 LCLT Program Status Codes (Error)**

The following table contains Error Status Codes that the LucidControl Command Line Tool returns when the arguments are parsed.

Status Code	Description
0x10	Internal I/O read error Accessing the communication interface (eg. COM1 or /dev/ttyACM0) failed because of communication errors (e.g. Timeouts)
0x11	Invalid number of bytes received Indicates that the number of received bytes in the LEN Field does not correspond to the number of received bytes in the Data Field
0x20	Invalid Channel Argument The passed channel Argument is wrong or it is missed
0x21	Invalid Multiple Channel Argument The passed channel argument is wrong or it is missed
0x2A	Invalid IO Value <ul style="list-style-type: none"> <li>• The value (writing) does not correspond to the expected number of values.</li> <li>• The value (writing) is not valid for the expected Value Type.</li> </ul>
0x30	Invalid Argument Baud Rate The port does not support the passed parameters.
0x40	Invalid or unknown Value Type The passed Value Type is incompatible or not supported.
0x31	Invalid Device Argument specified The device (serial port) is not available or busy (e.g. already opened).
0x4A	Invalid Configuration Parameter Argument
0x4B	Invalid Configuration Parameter Value Argument passed
0x90	More than one Command Argument passed

Tab. 4 LucidIoCtrl Command Line Tool Error Codes

### 3.3.2.2 LucidControl Module Status Codes (Error)

Tab. 4 explains the Error Codes that the LucidControl Module can return. While many errors like wrong Option Arguments can be detected by LCLT other errors cannot. E.g. reading a value from an obviously wrong input channel 9 by passing Option Argument `-c9` cannot be detected as wrong argument since LCLT does not know which capabilities a module have. Such errors can only be detected by the module itself.

Error Status Messages are documented in section 4.4 of this manual.

## 4 Communication and Commands

This chapter explains the LucidControl communication interface and the communication protocol.

While for most users it is not necessary to understand this in detail it could be most helpful for programmers implementing their own API (Application Programming Interface).

Since LucidControl uses the CDC profile of the USB standard it is possible to access LucidControl modules as common serial device which has several advantages:

- Standardized device driver of the operating system can be used and a driver installation is not necessary
- LucidControl can be controlled simple e.g. by using terminal programs
- Portable equipment running under Microsoft Windows<sup>®</sup> as well as Linux
- Newer releases of operating systems will support the device automatically

Based on the serial port LucidControl is controlled by simple data frames which are described in this following.

### 4.1 Communication Frame

The data exchanged between the computer and LucidControl are packed into communication frames.

Data sent to LucidControl are called Requests, data sent back from LucidControl are called Responses.

The communication follows a master-slave principle where LucidControl answers to Requests of the host only. LucidControl does not initiate a communication on its own.

#### 4.1.1 Request Frame

A Request Frame sent from a computer contains data for LucidControl and initiates a communication.

Header Field				Data Field
OPC	P1	P2	LEN	Data Field
1 Byte	1 Byte	1 Byte	1 Byte	LEN Bytes

Field	Description
OPC	Opcode for Request Command
P1, P2	Command specific Parameters
LEN	Number of Bytes in the Data Field
Data Field	Data Field

**Tab. 5 Request Frame**

Tab. 5 shows the fields of the Request Frame. The Header Field is mandatory and the Data Field is optional and only available if  $LEN > 0$ .

### 4.1.2 Response Frame

The Response Frame sent from LucidControl contains information for the host computer.

Header Field		Data Field
Status	LEN	Data Field
1 Byte	1 Byte	LEN Bytes

Field	Description
Status	Status Code
LEN	Number of Bytes in Data Field
Data Field	Data Field

**Tab. 6 Response Frame**

Tab. 6 explains the fields of the Response Frame. The Header Field is mandatory and the Data Field is optional and only available for  $LEN > 0$ .

Depending on the command and the execution status LucidControl may return more or less information.

In the case of success Status Code has a value of 0x00 and LEN indicates how many bytes the Data Field contains.

In the case of error the Status Word is not equal to 0x00 and the Length indicates with a value of 0x00 that the Data Field is absent. A detailed description of Error Status Codes can be found in section 4.4 of this manual.

## 4.2 Value Types

LucidControl handles various analog and digital signals. Commands accessing the inputs and outputs need specification of the Value Type in order to interpret the data correctly.

Tab. 7 describes the supported Value Types. The information if a LucidControl module supports a Value Type can be found in the module specific user manual.

Value Type	Description	Size
0x00	Digital Logic Value Value for digital inputs and outputs. Supported values are either "00" and "01".	1 Byte
0x0A	Digital Counter Value Input Counter for Digital Inputs. Value Range: 0 ~ 65,535	2 Bytes
0x10	Analog Value Value for analog inputs and outputs without unit or further specification. Value Range: 0 ~ 65,535	2 Bytes
0x1C	Voltage Value (signed) Voltage of analog inputs and outputs Resolution: 1 mV Value Range: -30,000 mV ~ 30,000 mV	2 Bytes
0x1D	Voltage Value (signed) Voltage for analog inputs and outputs Resolution: 1 $\mu$ V Value Range: -100,000,000 $\mu$ V ~ 100,000,000 $\mu$ V	4 Bytes
0x23	Current Value (signed) Current for analog inputs and outputs Resolution: 1 $\mu$ A Value Range: -1,000,000 $\mu$ A ~ 1,000,000 $\mu$ A	4 Bytes
0x40	Temperature Value (signed) Temperature of RTD inputs Resolution: 1/10 K Value Range: -1,000 °C ~ 1,000 °C Values: -10,000 ~ 10,000	2 Bytes
0x41	Temperature Value (signed) Temperature for RTD inputs Resolution: 1/100 K Value Range: -1,000 °C ~ 1,000 °C Values: -100,000 ~ 100,000	4 Bytes
0x50	Resistance Value Resistance Value of RTD inputs Resolution: 1/10 $\Omega$ Value Range: 0 ~ 5,000 $\Omega$	2 Bytes

Tab. 7 Value Types

Note

Values are represented in little-endian byte order.

Example

A voltage of 5 V is represented by a value of 5,000,000 by using Value Type 0x1D. In the case the value is read from a module the Response Frame looks like this:

Header Field		Data Field			
Status	LEN	Value			
0x00	0x04	0x40	0x4B	0x4C	0x00

### 4.3 Implemented Commands

This section explains all available commands supported by the LucidControl.

Whether a module implements a specific command or not can be found in the module specific documentation.

#### 4.3.1 GetIo

This command reads the value of a channel. For input and output channels the command returns the current state or value.

In the case that an output is read the command may return the state or value which was written to the output before.

Request Frame

OPC	P1	P2	LEN
0x46	Channel	Value Type	0

Value	Description
Channel	Number of input or output channel (Range: 0 ~ 3)
Value Type	See 4.2

**Tab. 8 GetIo Request**

Response Frame

In case of successful execution the command returns the value of the specified input channel.

Status	LEN	Data Field
Status	Size	Value

Size represents the length of the Value which can be found in section 4.2.

In the case of an error the command returns Execution Status Code documented in section 4.4.

Example

Read the Input channel 3 of a voltage input. The input channel returns -5V.

Request Frame

OPC	P1	P2	LEN
0x46	0x03	0x1D	0

Response Frame

Header Field		Data Field			
Status	LEN	Value			
0x00	0x04	0xC0	0xB4	0xB3	0xFF

**4.3.2 GetIoGroup**

This command reads a group of channel values. For input and output channels the command returns the current states or values.

In the case that an output is read the command may return the states or values which were written to the output before.

Request Frame

OPC	P1	P2	LEN
0x48	Channel Mask	Value Type	0

Value	Description															
Channel Mask	Channel Bit Mask specifying the channel number(s)															
	<table><tr><th>Channel</th><th>Bit Position</th><th>Value</th></tr><tr><td>0</td><td>0</td><td>0x01</td></tr><tr><td>1</td><td>1</td><td>0x02</td></tr><tr><td>2</td><td>2</td><td>0x04</td></tr><tr><td>3</td><td>3</td><td>0x08</td></tr></table>	Channel	Bit Position	Value	0	0	0x01	1	1	0x02	2	2	0x04	3	3	0x08
	Channel	Bit Position	Value													
	0	0	0x01													
	1	1	0x02													
	2	2	0x04													
	3	3	0x08													
Values can be bitwise combined.																
<u>Examples</u>																
Accessing channel numbers 0 and 3	Value = 0x01 OR 0x08 = 0x09															
Accessing channel numbers 1 and 2	Value = 0x02 OR 0x04 = 0x06															
Value Type	See 4.2															

**Tab. 9 GetIoGroup Request**

Response Frame

In case of successful execution the command returns the value of the input channels specified in the Channel Mask.

Status	LEN	Data Field
Status	Size	Value(s)

Size represents the length of the value(s) which can be found in section 4.2. In the case that more than one channel is read Size is a multiple of the size of one value.

In the case of an error the command returns Execution Status Code documented in section 4.4.

#### Example

Read the input channels 0 and 3 of an analog input. The input channel 0 returns -5V input channel 3 returns 5V.

#### Request Frame

OPC	P1	P2	LEN
0x48	0x09	0x1D	0

#### Response Frame

Header Field		Data Field							
Status	LEN	Value Channel 0				Value Channel 3			
0x00	0x08	0xC0	0xB4	0xB3	0xFF	0x00	0x40	0x4B	0x4C

### 4.3.3 SetIo

This Command assigns a value to an output channel.

#### Request Frame

OPC	P1	P2	LEN	Data
0x40	Channel	Value Type	Length	Value

Value	Description
Channel	Number output channel (Range: 0 ~ 3)
Value Type	See 4.2
Length	Size of the value (See 4.2)
Value	Value to write

Tab. 10 SetIo Request

#### Response Frame

Status	Length
Status	0

The command does not return any data.

In the case of an error the command returns Execution Status Code documented in section 4.4.

Example

Set the digital output channel 1 to "High"

Request Frame

OPC	P1	P2	LEN	Data
0x40	0x01	0x00	0x01	0x01

Response Frame

Status	Length
0x00	0x00

**4.3.4 SetIoGroup**

This command writes values of the same value type to multiple output channels.

Request Frame

OPC	P1	P2	LEN	Data
0x42	Channel Mask	Value Type	Length	Value(s)

Value	Description															
Channel Mask	Channel Bit Mask specifying the channel number(s)															
	<table><tr><th>Channel</th><th>Bit Position</th><th>Value</th></tr><tr><td>0</td><td>0</td><td>0x01</td></tr><tr><td>1</td><td>1</td><td>0x02</td></tr><tr><td>2</td><td>2</td><td>0x04</td></tr><tr><td>3</td><td>3</td><td>0x08</td></tr></table>	Channel	Bit Position	Value	0	0	0x01	1	1	0x02	2	2	0x04	3	3	0x08
	Channel	Bit Position	Value													
	0	0	0x01													
	1	1	0x02													
	2	2	0x04													
	3	3	0x08													
Values can be bitwise combined.																
<u>Examples</u>																
Accessing channel number 0 and 3	Value = 0x01 OR 0x08 = 0x09															
Accessing channel number 1 and 2	Value = 0x02 OR 0x04 = 0x06															
Value Type	See 4.2															
Value(s)	One or more values to set															

**Tab. 11 SetIoGroup Request**

Response Frame

Status	Length
Status	0

The command does not return any data.

In the case of an error the command returns Execution Status Code documented in section 4.4.

Example

Set output channels 0 and 3 of a voltage output to 2.5 V and 5.0 V.

Request Frame

OPC	P1	P2	LEN	Data Field							
0x42	0x09	0x1D	0x08	Value Channel 0				Value Channel 3			
				0x00	0xA0	0x25	0x26	0x00	0x40	0x4B	0x4C

Response Frame

Status	Length
0x00	0x00

**4.3.5 SetParam**

This command sets System Configuration Parameters of the module and IO Configuration Parameters of the inputs or outputs.

Request Frame

OPC	P1	P2	LEN	Data Field	
0xA0	Channel	Option	Length	P-Address	P-Value

Value	Description									
Channel	Channel number for input or output channel configuration parameters									
Option	Parameter Set Options									
	<table><tr><th>Bit Position</th><th>Value</th><th>Description</th></tr><tr><td>0</td><td>0x01</td><td>Set Default If bit is set the parameter value is set to its default value. Length must be set to 0 and Data Field must be omitted.</td></tr><tr><td>7</td><td>0x80</td><td>Persistent Parameter Parameter is saved and restored on module startup.</td></tr></table>	Bit Position	Value	Description	0	0x01	Set Default If bit is set the parameter value is set to its default value. Length must be set to 0 and Data Field must be omitted.	7	0x80	Persistent Parameter Parameter is saved and restored on module startup.
	Bit Position	Value	Description							
	0	0x01	Set Default If bit is set the parameter value is set to its default value. Length must be set to 0 and Data Field must be omitted.							
	7	0x80	Persistent Parameter Parameter is saved and restored on module startup.							
Values can be bitwise or combined										
Length	Length of the Data Field containing parameter address and parameter value. Must be at least 0x02 which is the length of the parameter address.									
P-Address	Parameter Address This value specifies the 2 Byte address of the parameter Addresses of system parameters can be found in section 0. Adresses of IO configuration parameters can be found in the module specific documentation.									
P-Value	Parameter Value									

Tab. 12 SetParam Request

Response Frame

Status	Length
Status	0

The command does not return any data.

In the case of an error the command returns Execution Status Code documented in section 4.4.

Example

Set the IO configuration parameter *outDiCycleTime* (Parameter Address = 0x1110) of output channel 0 to 750 ms and make it persistent. The parameter has a length of 4 Bytes.

Request Frame

OPC	P1	P2	LEN	Data Field					
0xA0	0	0x80	0x06	P-Address		P-Value			
				0x10	0x11	0xB0	0x71	0x0B	0x00

Response Frame

Status	Length
0x00	0x00

**4.3.6 GetParam**

This command read System Configuration Parameters of the module and IO Configuration Parameters of the inputs or outputs.

Request Frame

OPC	P1	P2	LEN	Data
0xA2	Channel	0x00	0x02	P-Address

Value	Description
Channel	Channel number for input or output channel configuration parameters
P-Address	Parameter Address This value specifies the 2 Byte address of the parameter Addresses of system parameters can be found in section 0. Addresses of IO configuration parameters can be found in the module specific documentation.

Response Frame

In case of successful execution the command returns the value of the specified parameter value.

Status	LEN	Data Field
Status	Size	P-Value

In the case of an error the command returns Execution Status Code documented in section 4.4.

Example

Read the parameter *outDiCycleTime* (Parameter Address = 0x1110) of output channel 0. The command returns a value of 750 ms.

Request Frame

OPC	P1	P2	LEN	Data	
0xA2	0x00	0x00	0x02	P-Address	
				0x10	0x11

Response Frame

Status	LEN	Data Field			
0x00	0x04	0xB0	0x71	0x0B	0x00

**4.3.7 CalibrateIo**

This command performs LucidControl module dependent calibration sequence.

More information can be found in the module specific documentation.

Request Frame:

OPC	P1	P2	LEN
0x52	Channel	Option	0

Value	Description
Channel	Channel number for input or output calibration
Option	Calibration command specific option depending on the used module.
LEN	Data Field is absent

Response Frame

Status	Length
Status	0

The command does not return any data.

In the case of an error the command returns Execution Status Code documented in section 4.4.

**4.3.8 GetId**

This command returns the Identification Data Block of the LucidControl module.

Request Frame

OPC	P1	P2	LEN
0xC0	0x00	Option	0

Value	Description		
Option	Get Identification Option		
	Bit Position	Value	Description
	0	0x01	Blink If set the parameter value is set the STATE Led of the module blinks once. This can help to find a specific module.

**Tab. 13 GetId Request**Response Frame

In case of successful execution the command returns the value of the identification data block.

Status	LEN	Data Field					
Status	0x10	Firmware Revision	Hardware Revision	Device Class	Device Type	Device Serial No.	Reserved

In the case of an error the command returns Execution Status Code documented in section 4.4.

## 4.4 Execution Status Codes and Messages

Tab. 14 shows the Execution Status Codes which LucidControl can return and the corresponding Execution Status Messages.

Status Code	Status	Status Message
0x00	OK	Success
0xA0	NO_SUPPORT	Command not supported
0xB0	INV_LENGTH	Invalid data length
0xB2	INV_P1	Invalid Parameter P1
0xB4	INV_P2	Invalid Parameter P2
0xB6	INV_VALUE	Invalid Value or Value Type
0xB8	INV_CHANNEL	Invalid IO Channel
0xBA	INV_PARAM	Invalid Parameter Address
0xC0	INV_DATA	Invalid data in Data Field
0xD0	ERR_EXECUTION	Error during command execution

**Tab. 14 Execution Status Codes**